US008363656B2

(12) **United States Patent**
Klink et al.

(10) **Patent No.: US 8,363,656 B2**
(45) **Date of Patent: Jan. 29, 2013**

(54) **MULTIPLE VIRTUAL MACHINES SHARING A SINGLE IP ADDRESS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 198 days.

(21) Appl. No.: **12/882,795**

(22) Filed: **Sep. 15, 2010**

(65) **Prior Publication Data**

US 2012/0063458 A1 Mar. 15, 2012

(51) **Int. Cl.**
H04L 12/28 (2006.01)
H04L 12/56 (2006.01)

(52) **U.S. Cl.** **370/392**

(58) **Field of Classification Search** 370/392
See application file for complete search history.

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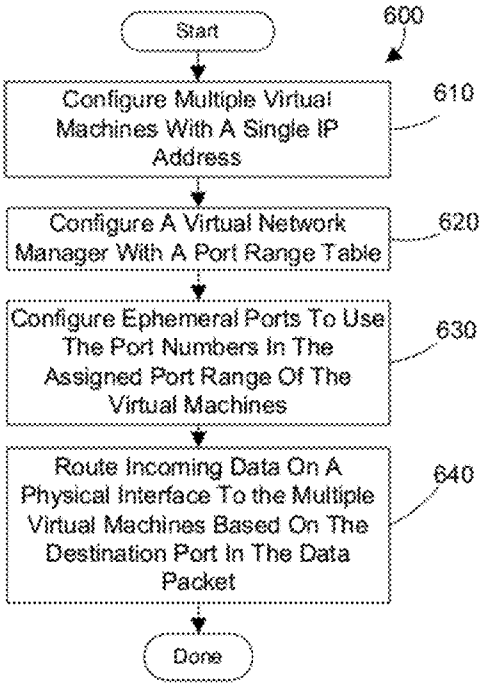
(57) **ABSTRACT**

A method and apparatus allow multiple virtual machines to share the same IP address on an external network address space. The virtual machines reside on one or more physical host computer systems. A virtual network manager handles network traffic from a physical interface on the host computer and forwards network data to the appropriate virtual machine based on a destination port number. Data packets on the external network each have a destination and source port number. The virtual network manager uses a port range table that associates each virtual machine with a range of destination port numbers for incoming data packets. Each of the virtual machines is assigned a unique destination port range in the port range table and incoming data traffic on the external network is routed to the receiving virtual machines based on the destination port number in the data packet.

18 Claims, 5 Drawing Sheets


Start
600
Configure Multiple Virtual Machines With A Single IP Address
610
Configure A Virtual Network Manager With A Port Range Table
620
Configure Ephemeral Ports To Use The Port Numbers In The Assigned Port Range Of The Virtual Machines
630
Route Incoming Data On A Physical Interface To the Multiple Virtual Machines Based On The Destination Port In The Data Packet
640
Done

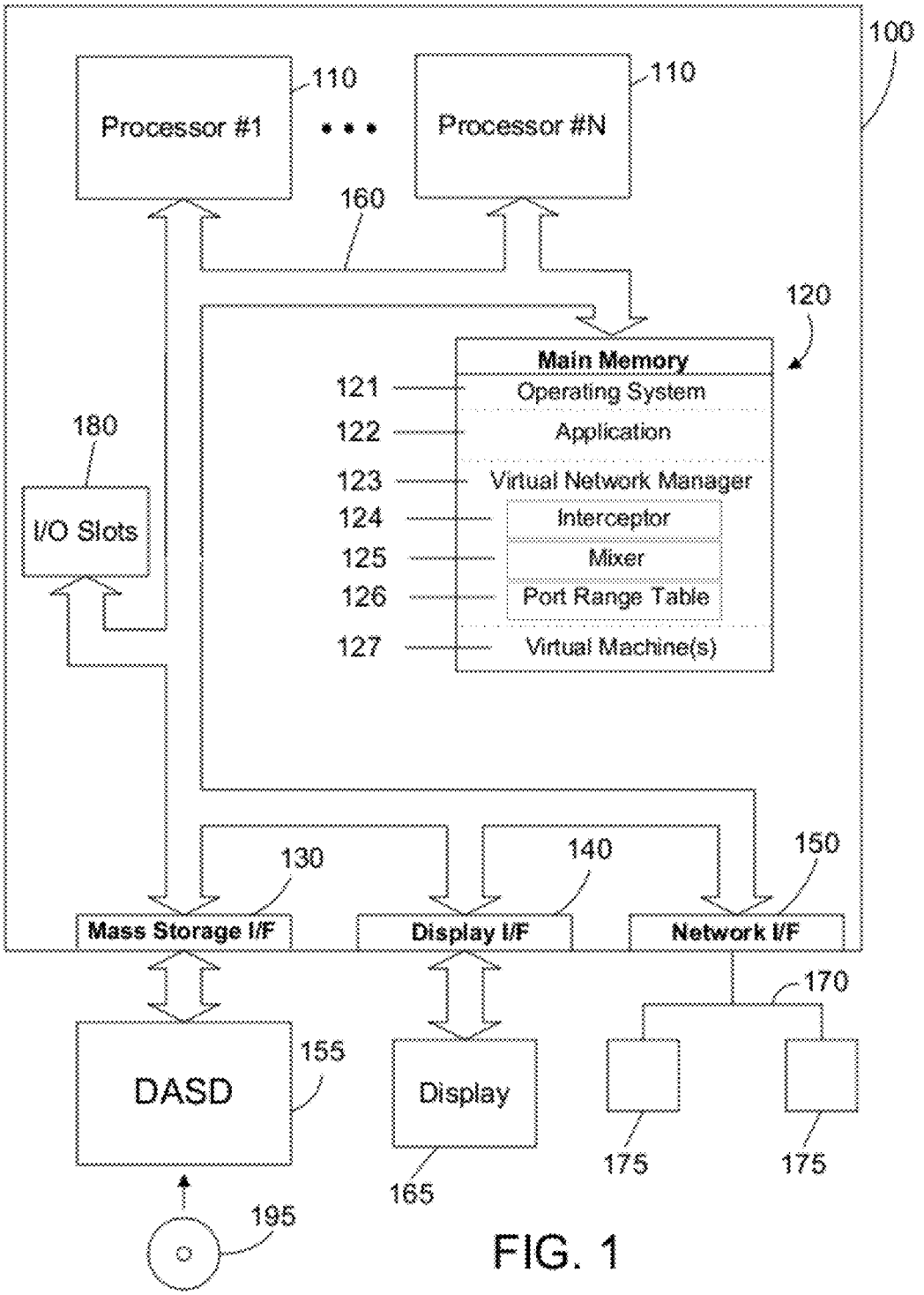

100
Processor #1
110
Processor #N
110
160
120
Main Memory
121
Operating System
122
Application
123
Virtual Network Manager
124
Interceptor
125
Mixer
126
Port Range Table
127
Virtual Machine(s)
180
I/O Slots
130
140
150
Mass Storage I/F
Display I/F
Network I/F
170
DASD
155
Display
165
175
175
195

FIG. 1

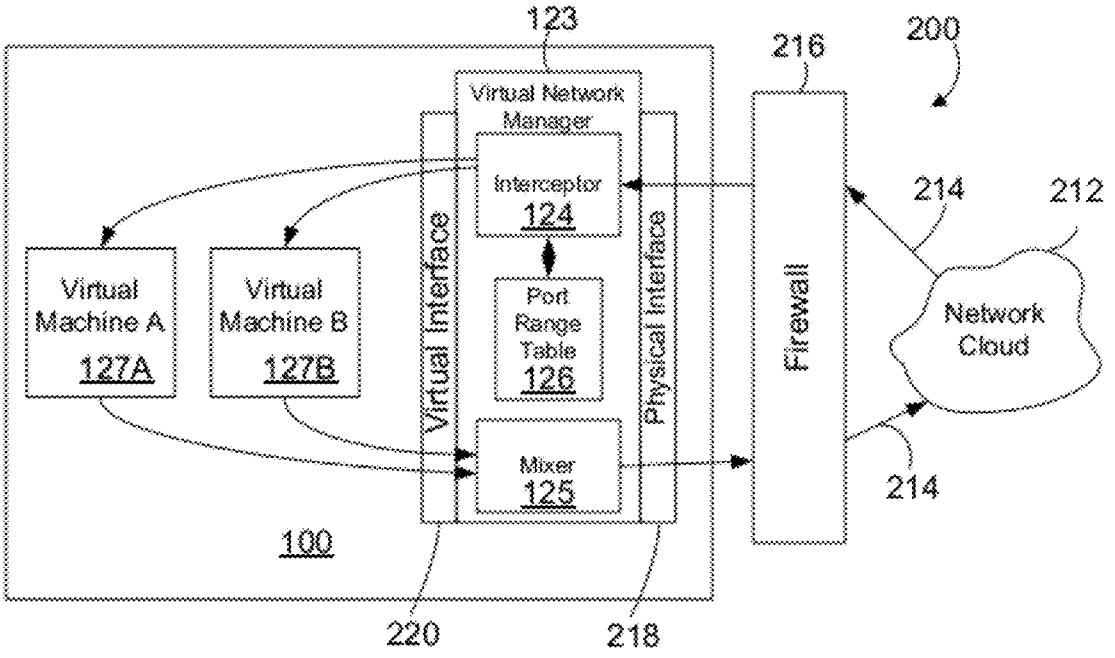


FIG. 2

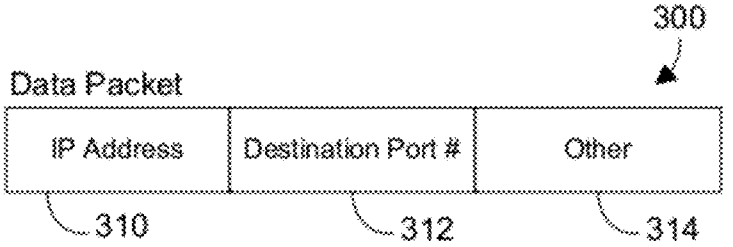


FIG. 3

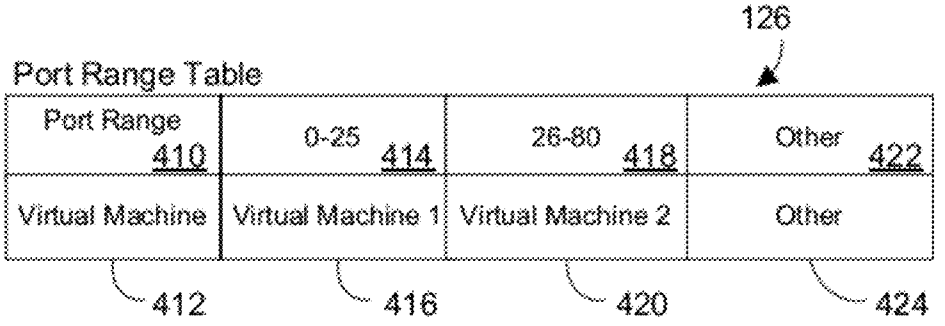


FIG. 4

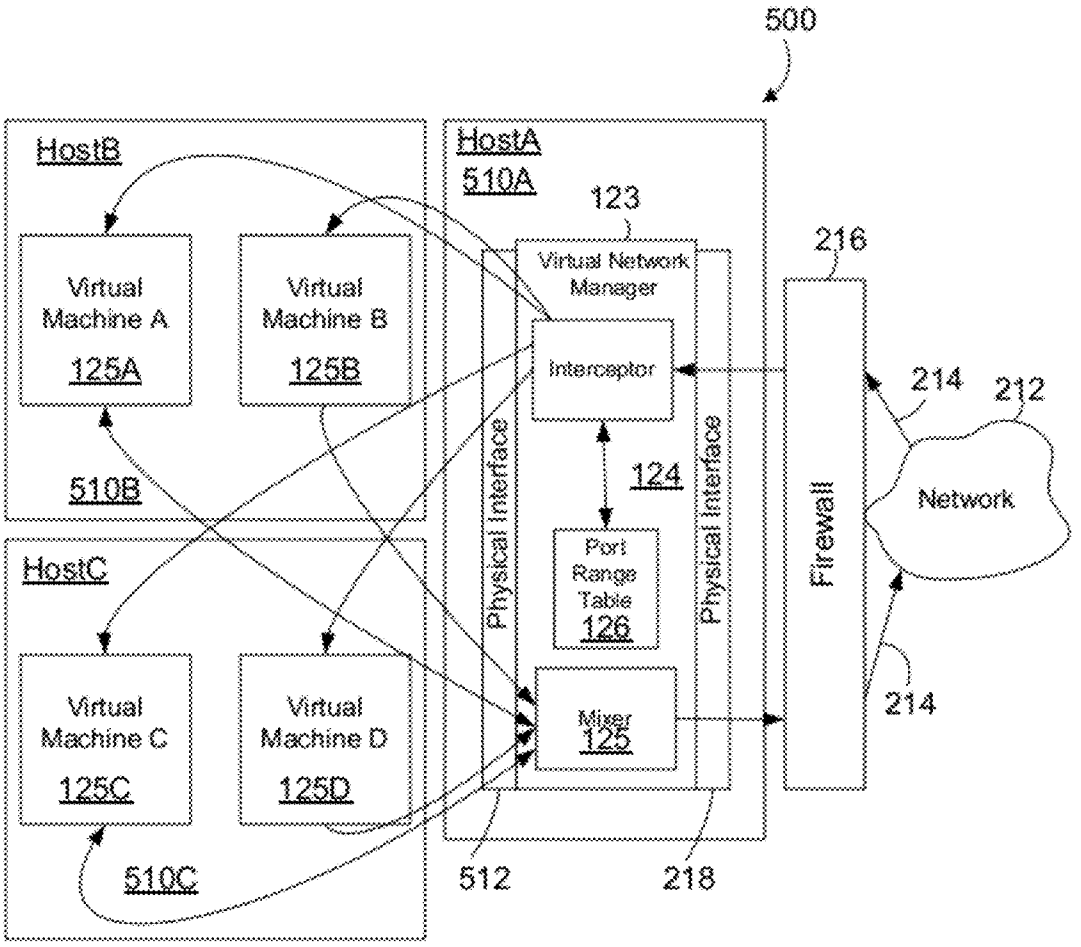

500
HostB
Virtual Machine A
125A
Virtual Machine B
125B
510B
HostC
Virtual Machine C
125C
Virtual Machine D
125D
510C
HostA
510A
123
Virtual Network Manager
Interceptor
124
Port Range Table
126
Mixer
125
Physical Interface
Physical Interface
216
Firewall
214
212
Network
214
512
218

FIG. 5

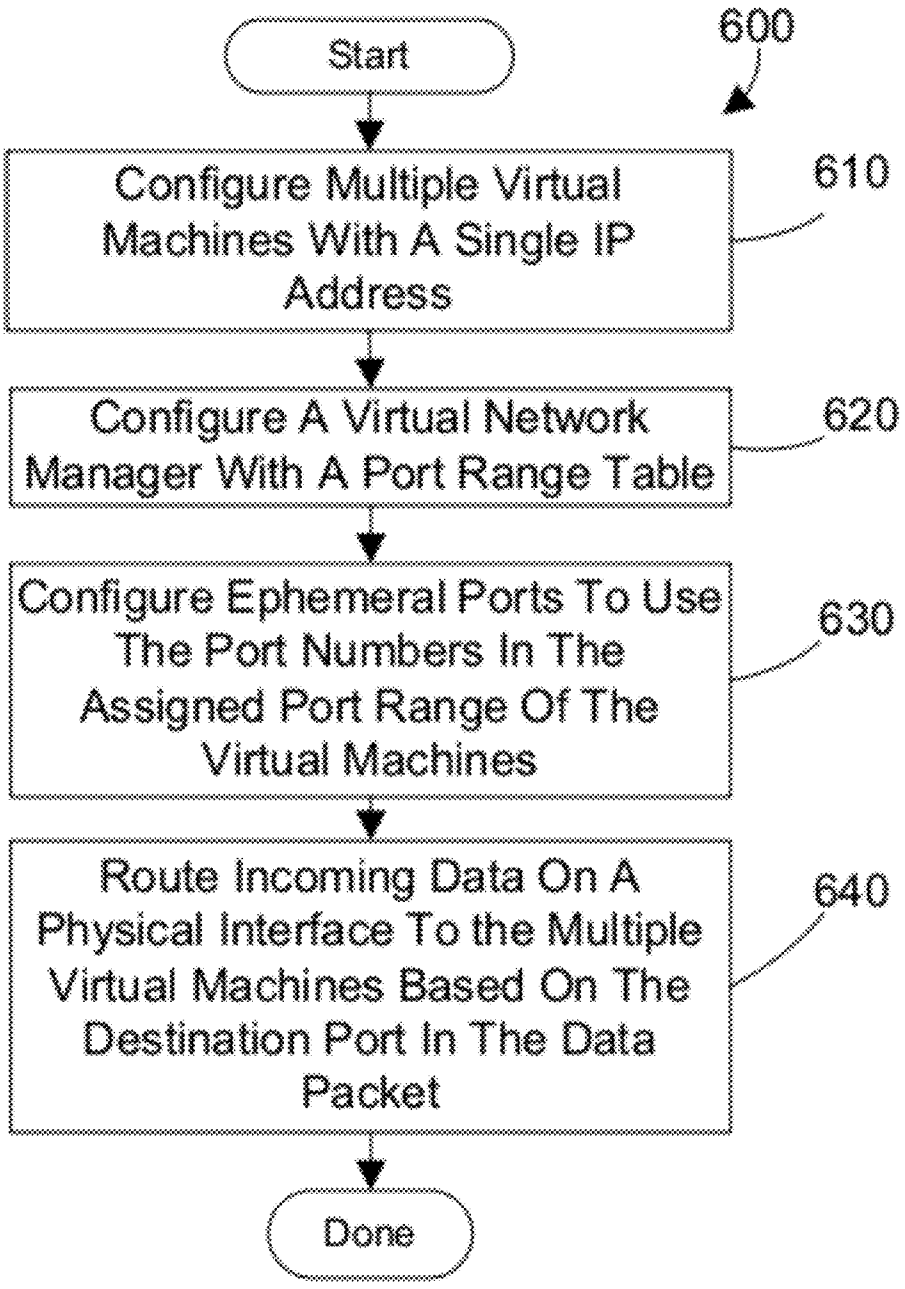

600
Start
Configure Multiple Virtual Machines With A Single IP Address
610
Configure A Virtual Network Manager With A Port Range Table
620
Configure Ephemeral Ports To Use The Port Numbers In The Assigned Port Range Of The Virtual Machines
630
Route Incoming Data On A Physical Interface To the Multiple Virtual Machines Based On The Destination Port In The Data Packet
640
Done

FIG. 6

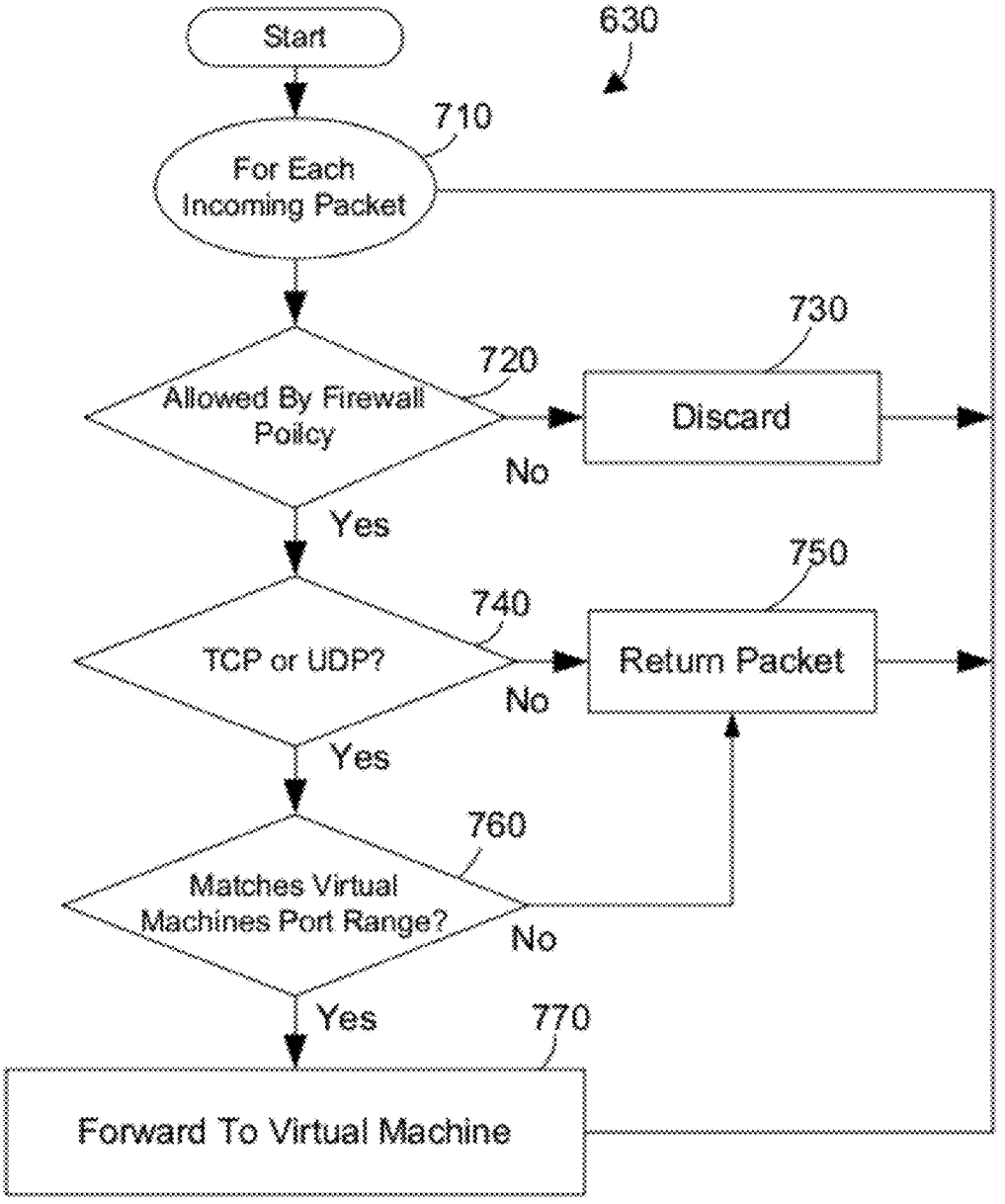

630
Start
710
For Each Incoming Packet
720
Allowed By Firewall Policy
No
730
Discard
Yes
740
TCP or UDP?
No
750
Return Packet
Yes
760
Matches Virtual Machines Port Range?
No
Yes
770
Forward To Virtual Machine

FIG. 7

MULTIPLE VIRTUAL MACHINES SHARING A SINGLE IP ADDRESS

BACKGROUND

1. Technical Field

This disclosure generally relates to computer systems, and more specifically relates to sharing a single IP address among multiple virtual machines residing on one or more physical host computers.

2. Background Art

A single host computer may hold multiple virtual instances of a computer referred to as a virtual machine. A virtual machine is sometimes defined as an efficient and isolated duplicate of a real machine. A virtual machine is thus a duplicate or instance of a virtual computer residing on a physical host computer. A virtual machine is sometimes also called a logical partition. A principle advantage of a virtual machine system is that multiple operating system (OS) environments can co-exist on the same computer in isolation from each other. In addition, a virtual machine can provide an instruction set architecture that is different from that of the real machine. A virtual machine can be utilized to improve application provisioning, maintenance, high availability and disaster recovery.

Virtual machines residing on a physical host computer typically must share a physical network interface of the host computer. The physical network interface of the host computer is connected to an external network. As used herein, an external network is any network residing outside of a single physical machine and may/may not be indirectly contacted through a series of firewalls. In some cases, it is advantageous to have a single IP address from the external network address space assigned to the physical interface of the host computer. Virtual machines residing on the host have their own virtual network interfaces connected to the same external network via the host physical interface. In the prior art, there have been various approaches to having multiple virtual machines use the same physical network interface.

BRIEF SUMMARY

The disclosure and claims herein are directed to multiple virtual machines (virtual computers) that collectively are assigned the same IP address on an external network address space. The virtual machines reside on one or more physical host computer systems. A virtual network manager handles network traffic from a physical interface on the host computer and forwards network data to the appropriate virtual machine based on a destination port number. Data packets on the external network each have a destination and source port number. The virtual network manager uses a port range table that associates each virtual machine with a range of destination port numbers for incoming data packets. Each of the virtual machines is assigned a unique destination port range in the port range table and incoming data traffic on the external network is routed to the receiving virtual machines based on the destination port number in the data packet.

The foregoing and other features and advantages will be apparent from the following more particular description, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING(S)

The disclosure will be described in conjunction with the appended drawings, where like designations denote like elements, and:

FIG. **1** is a block diagram of a computer system with a virtual network manager utilizing a port range table to enable multiple virtual computers to use a single network IP address as described herein;

FIG. **2** is a block diagram that illustrates how data packets are routed to multiple virtual machines residing on a host computer by a virtual network manager;

FIG. **3** is a block diagram that represents a data packet sent over the network described herein;

FIG. **4** is a block diagram that shows an example of a port range table;

FIG. **5** is a block diagram similar to FIG. **1** that illustrates multiple physical hosts with virtual machines utilizing the same IP address;

FIG. **6** is a method flow diagram for sharing a single IP address among multiple virtual machines; and

FIG. **7** is an example of a method flow diagram for routing incoming data to multiple virtual machines based on a port range table according to step **630** in FIG. **6**.

DETAILED DESCRIPTION

Described herein is an apparatus and method for multiple virtual machines to share the same IP address on an external network address space. The virtual machines reside on one or more physical host computer systems. A virtual network manager handles network traffic from a physical interface on the host computer and forwards network data to the appropriate virtual machine based on a destination port number. Data packets on the external network each have a destination and source port number. The virtual network manager uses a port range table that associates each virtual machine with a range of destination port numbers for incoming data packets. Each of the virtual machines is assigned a unique destination port range in the port range table and incoming data traffic on the external network is routed to the receiving virtual machines based on the destination port number in the data packet.

Referring to FIG. **1**, a computer system **100** is one suitable implementation of a computer system that includes a virtual network manager as described herein. Computer system **100** is an International Business Machines Corporation (IBM®) Power System which can run multiple operating systems including the IBM® i operating system and Linux operating system. However, those skilled in the art will appreciate that the disclosure herein applies equally to any computer system capable of being connected to an external network. As shown in FIG. **1**, computer system **100** comprises one or more processors **110**, a main memory **120**, a mass storage interface **130**, a display interface **140**, and a network interface **150**, and a plurality of I/O slots **180**. These system components are interconnected through the use of a system bus **160**. Mass storage interface **130** is used to connect mass storage devices with a computer readable medium, such as direct access storage devices **155**, to computer system **100**. One specific type of direct access storage device **155** is a readable and writable CD-RW drive, which may store data to and read data from a CD-RW **195**. Note that mass storage interface **130**, display interface **140**, and network interface **150** may actually be implemented in adapters coupled to I/O slots **180**. An I/O adapter is one suitable network interface **150** that may be implemented in an external card that is plugged into one of the I/O slots **180**. In addition, other I/O devices such as modems can be plugged into one of the I/O slots **180**.

Main memory **120** preferably contains an operating system **121**. Operating system **121** is preferably a multitasking operating system, such as AIX, or Linux; however, those skilled in

the art will appreciate that the spirit and scope of this disclosure is not limited to any one operating system. Any suitable operating system can be used. Operating system **121** is a sophisticated program that contains low-level code to manage the resources of computer system **100**. Some of these resources are processors **110**, main memory **120**, mass storage interface **130**, display interface **140**, network interface **150**, system bus **160**, and I/O slots **180**. Each virtual machine may also have an operating system. The operating system in each virtual machine or partition may be the same as the operating system in virtual machines, or may be a completely different operating system. Thus, one virtual machine can run the AIX operating system, while a different virtual can run another instance of AIX, possibly a different release, or with different environment settings (e.g., time zone or language). In this manner the virtual machines can provide completely different computing environments on the same physical computer system. The memory further includes a software application **122**. The memory includes a virtual network manager **123**. The virtual network manager includes an interceptor **124**, a mixer **125** and a port range table **126**. The memory also includes one or more virtual machines or computers **127**. Each of these entities in the memory is described further below.

The virtual machine(s) **127** are shown to reside within main memory **120**. However, one skilled in the art will recognize that a virtual machine (or logical partition) is a logical construct that includes resources other than memory. A virtual machine **127** typically specifies a portion of memory, along with an assignment of processor capability an other system resources, such as I/O slots **180** and I/O adapters, which may reside in I/O slots **180**. Thus, one virtual machine could be defined to include two processors and a portion of memory **120**, along with one or more I/O processors that can provide the functions of mass storage interface **130**, display interface **140**, network interface **150**, or interfaces to I/O adapters or other devices (such as modems) plugged into I/O slots **180**. Another virtual machine could then be defined to include three other processors, a different portion of memory **120**, and one or more I/O processors. The virtual machine(s) is shown in FIG. **1** to symbolically represent virtual machines or logical partitions, which would include system resources outside of memory **120** within computer system **100**.

Computer system **100** utilizes well known virtual addressing mechanisms that allow the programs of computer system **100** to behave as if they only have access to a large, single storage entity instead of access to multiple, smaller storage entities such as main memory **120** and DASD device **155**. Therefore, while operating system **121**, application **122**, virtual network manager **123** and the virtual machine(s) **127** are shown to reside in main memory **120**, those skilled in the art will recognize that these items are not necessarily all completely contained in main memory **120** at the same time. It should also be noted that the term "memory" is used herein generically to refer to the entire virtual memory of computer system **100**, and may include the virtual memory of other computer systems coupled to computer system **100**.

Processor **110** may be constructed from one or more microprocessors and/or integrated circuits. Processor **110** executes program instructions stored in main memory **120**. Main memory **120** stores programs and data that processor **110** may access. When computer system **100** starts up, processor **110** initially executes the program instructions that make up operating system **121** and later executes the program instructions that make up the application **122** and the virtual network manager **123**.

Although computer system **100** is shown to contain only a single processor and a single system bus, those skilled in the art will appreciate that a virtual network manager may be practiced using a computer system that has multiple processors and/or multiple buses. In addition, the interfaces that are used preferably each include separate, fully programmed microprocessors that are used to off-load compute-intensive processing from processor **110**. However, those skilled in the art will appreciate that these functions may be performed using I/O adapters as well.

Display interface **140** is used to directly connect one or more displays **165** to computer system **100**. These displays **165**, which may be non-intelligent (i.e., dumb) terminals or fully programmable workstations, are used to provide system administrators and users the ability to communicate with computer system **100**. Note, however, that while display interface **140** is provided to support communication with one or more displays **165**, computer system **100** does not necessarily require a display **165**, because all needed interaction with users and other processes may occur via network interface **150**, e.g. web client based users.

Network interface **150** is used to connect computer system **100** to other computer systems or workstations **175** via network **170**. Network interface **150** broadly represents any suitable way to interconnect electronic devices, regardless of whether the network **170** comprises present-day analog and/or digital techniques or via some networking mechanism of the future. In addition, many different network protocols can be used to implement a network. These protocols are specialized computer programs that allow computers to communicate across a network. TCP (Transmission Control Protocol) and User Datagram Protocol (UDP) are examples of suitable network protocols.

FIG. **2** illustrates a block diagram for a host computer with multiple virtual machines to share the same IP address on an external network address space. The host computer **100** in FIG. **2** is the host computer described above with reference to FIG. **1** or a similar computer system. The host computer **100** is connected to a network cloud **212** by a physical network **214**. The network cloud represents an external network of computers connected together and communicating with the host computer **100**. Data communications from other computers in the network cloud **212** flows to the host computer **100** through a Firewall **216**. Data is sent to the host computer over the network **214** in data packets according to different data protocols. The data packets are routed to multiple virtual machines **127**A, **127**B residing on the host computer **100** by a virtual network manager **123**. The virtual network manager **123** receives the data packets on a physical interface **216** and then sends the data packets to the appropriate virtual machine using a virtual interface **220**. The virtual network manager has an interceptor **124** that manages incoming data and a mixer **125** that manages outgoing data. The mixer **125** receives outgoing packets from the virtual machines **127**A, **127**B and sends them to the external network **212**. The interceptor **124** intercepts incoming traffic to the shared address and depending on the target port either sends it to the destination virtual machine via the via the virtual interface or returns it back to the host networking stack if the destination port does not match any of assigned port ranges. The interceptor uses a port range table **126** to determine where to send each data packet. The interceptor looks at the destination port number in the data packet and sends the data packet to the virtual machine assigned to receive data packets with that particular destination port number as determined by the port range table **126**.

FIG. **3** is a block diagram that represents a highly simplified diagram of a data packet used for data communication on

the external network. The data packed may be a TCP or UDP data packet as known in the art. The data packet **300** includes an IP address **310** and a destination port number **312**. Other elements **314** of the data packet are not described here but are well known in the art.

FIG. **4** illustrates a table that represents one suitable implementation of a port range table **126** used by the interceptor **124** (FIG. **2**) in the virtual network manager **123** (FIG. **2**). The port range table **126** is preferably a file of records stored in memory, in a data storage device, or both. The port range table **126** includes a plurality of destination port ranges **410** and an associated virtual machine **412** for each port range. A port range **410** defines one or more destination port numbers that are used by the virtual network manager to route data to the corresponding virtual machine **412**. In the illustrated example, a port range of 0-25 **414** is associated with Virtual Machine **1** **416**, and a port range of 26-80 **418** is associated with Virtual Machine **2** **420**. The port range table **126** may include any number of other port ranges as indicated by the "other" range **422** associated with the other virtual machine **424**. The port range table **126** may be stored in any suitable format to show a logical condition between the port ranges and virtual machines as described herein. An entire port range may be closed on the host computer to disable packets for an entire virtual machine thus simplifying system administration when managing virtual machines on the host.

For TCP and UDP protocols, a single IP address has a limited number of destination ports and port numbers typically may not conflict between applications when using one IP address. One IP address may permit only one application on a virtual machine to be the receiver of communication to a certain port. For example, only one virtual machine can use the TCP port **21** for communication where only one IP address exists as described herein. By allowing the address space visible to the virtual machine to belong to the external network address space, the address space of the virtual machines is transparent to all protocols including peer to peer protocols and Voice over IP protocols.

Both the mixer **125** and interceptor **124** are located behind the host firewall **216** thus protecting virtual machines from external threats. Firewalls for the host system and client system may remain unchanged. Since the shared IP address is seen as 'local' to the host, it treats any packet rule as though it is a local rule and directing it for a local application. A secondary firewall or rule set is not required since only one IP address is used.

In the preferred example described above, all the virtual machines are configured to use the same IP address on the network interface. Each virtual machine is assigned a unique port range, which may consist of one or more non-contiguous ranges. All applications that are accepting incoming TCP or UDP packets are configured to use ports from the assigned range only as these will be the only known incoming/outgoing ports. The virtual machine operating systems may be configured to use ephemeral ports from the assigned range. Ephemeral ports are used as temporary ports in outgoing TCP and UDP packets. The virtual machines assign the source port on outgoing messages in the same range of ports assigned to the virtual machine in the port range table so that returning messages will return to the proper virtual machine. The host is configured to intercept packets sent to the shared IP address assigned to virtual machines and to forward into the destination machine based on the packet destination port number. All outgoing packets are typically transmitted to the external network unmodified. If the host is also using the shared IP address, a unique port range is assigned to the host. In this case the host is allocating permanent and ephemeral ports from this range. The packets received by the host for the shared address are intercepted by interceptor and directed to a virtual machine. If the host is using the shared IP, all packets that are not matched by the one of virtual machine port range are returned back to the host networking stack.

FIG. **5** illustrates is a block diagram for a computer system with multiple virtual machines that share the same IP address on an external network address space. The computer system of FIG. **5** is similar to the system shown in FIG. **2** but shows an example of how the system can be scaled to multiple physical host computers. In FIG. **5**, the host computer **510**A has a virtual network manager **123** similar to the host computer **100** described in FIG. **2**. In contrast to the system in FIG. **2**, the virtual network manager **123** in FIG. **5** communicates with virtual machines that reside on one or more other hosts. In the example shown, the virtual network manager **123** sends data packets to Virtual Machine A **125** A and virtual Machine B **125**B on HostB **510**B, and Virtual Machine C **125** C and virtual Machine D **125**D on HostC **510**C. In this case, the virtual network manager handles communication to the virtual machines on different physical host computers over a physical network **512** rather than a virtual network between the host computers **510**A, **510**B, **510**C. The connection to the virtual machines on the other hosts computers can use any suitable physical network connection. This architecture allows a virtual machine to migrate to a different physical host without changing the IP address.

FIG. **6** shows a method **600** for assigning the same IP address on an external network to multiple virtual computers as claimed herein. The steps in method **600** are preferably performed by the virtual network manager **123** (FIG. **1**), but portions of the method may also be performed by other software associated with the computer system or by a system administrator. First, configure multiple virtual machines to use a single IP address (step **610**). Next, configure a port range table with a range of ports for each virtual machine (step **620**). Then, configure ephemeral ports of each of the virtual machines to use source port numbers in the assigned port range for the virtual machine in the port range table (step **630**). Then route incoming data on a physical interface to the multiple virtual machines based on a destination port number in the data packet (step **640**). The method is then done.

FIG. **7** shows a method **630** for routing data on a physical interface to multiple virtual machines based on the port range table. Method **630** is an example of performing the step **630** in FIG. **6** according to the examples described in the previous paragraph. The steps in method **630** are preferably performed by the virtual network manager **123** (FIG. **1**), but portions of the method may also be performed by other software associated with the computer system. Method **630** is performed for each new incoming data packet on the physical interface (step **710**). Next, the data packed is checked by the firewall (step **720**). If the data packet is not allowed by the firewall (step **720**=no), then the data packed is discarded (step **730**) and the method returns to step **710**. If the data packet is allowed by the firewall (step **720**=yes), then check if the data packed conforms to the TCP or UDP protocols (step **740**). If the data packet does not conform to the TCP or UDP protocols (step **740**=no) then return the packet (step **750**) and return to step **710**. If the data packet does conform to the TCP or UDP protocols (step **740**=yes) then determine if the destination port number of the packet matches a destination port number in a port range for a virtual machine in the port range table (step **760**). If the destination port number of the packet does not matches a destination port number in the port range table (step **760**=no) then return the packet (step **750**) and return to step **710**. If the destination port number of the packet does

matches a destination port number in the port range table (step **760**=yes), then forward the data packet to a unique one of the virtual machines depending on the destination port number in the data packet (step **770**) and return to step **710**. In the embodiment described above, the virtual machine number of the unique virtual machine to forward the packet is determined by selecting the virtual machine number stored in the port range table corresponding to a port range that includes the destination port number in the data packet.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

As will be appreciated by one skilled in the art, aspects of the present invention may be embodied as a system, method or computer program product. Accordingly, aspects of the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, aspects of the present invention may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

Any combination of one or more computer readable medium(s) may be utilized. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device. A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device. Program code embodied on a computer readable medium may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

Computer program code for carrying out operations for aspects of the present invention may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider). Aspects of the present invention are described below with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks. The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

One skilled in the art will appreciate that many variations are possible within the scope of the claims. While the examples herein are described in terms of time, these other types of thresholds are expressly intended to be included within the scope of the claims. Thus, while the disclosure is particularly shown and described above, it will be understood by those skilled in the art that these and other changes in form and details may be made therein without departing from the spirit and scope of the claims.

The invention claimed is:

1. An apparatus comprising:

a host computer system with a processor and a memory;

a physical interface with a single internet protocol (IP) address connecting the host computer to an external network;

a plurality of virtual machines each with a virtual machine number in the memory;

a data packet with a destination port number received on the physical interface;

a virtual network manager that forwards the data packet to a unique one of the plurality of virtual machines depending on the destination port number in the data packet; and

a port range table with a plurality of port ranges and a corresponding virtual machine number for each port range, and wherein the virtual network manager determines the virtual machine number of the unique one of the plurality of virtual machines by selecting the virtual machine number stored in the port range table corresponding to a port range that includes the destination port number in the data packet.

2. The apparatus of claim **1** further comprising a firewall protecting the host computer from the external network.

3. The apparatus of claim **1** wherein the plurality of virtual machines are located on a plurality of host computer systems.

4. The apparatus of claim **1** and wherein the virtual network manager forwards the data packet to the virtual machine on a virtual network.

5. The apparatus of claim **1** wherein the data packets conform to a protocol chosen from the following: TCP (Transmission Control Protocol) and User Datagram Protocol (UDP).

6. The apparatus of claim **1** wherein ephemeral ports of the virtual machines are configured to use port numbers in a range of port numbers in the port range table assigned to the virtual machine.

7. A computer-implemented method for sending data to a virtual machine on a host computer system, the method comprising the steps of:

(A) configuring multiple virtual machines with a single internet protocol (IP) address;

(B) configuring a virtual network manager with a port range table with a plurality of port ranges and a corresponding virtual machine number for each port range;

(C) configuring ephemeral ports of the virtual machines to use port numbers in a range of port numbers in the port range table assigned to the virtual machine; and

(D) routing an incoming data packet from a physical interface to a unique one of the multiple virtual machines based on a destination port number in the data packet.

8. The method of claim **7** wherein the step of routing the incoming data packet further comprises:

determining a virtual machine number corresponding to the destination port number in the data packet, where the destination port number matches a port range in the port range table and routing the data packet to the unique one virtual machine with the determined virtual machine number.

9. The method of claim **7** further comprising the steps of:

(E) discarding the incoming packet where the incoming packet is not allowed by a firewall; and

(F) returning the incoming packet if the packet does not conform to a protocol chosen from the following: TCP (Transmission Control Protocol) and User Datagram Protocol (UDP.

10. The method of claim **7** wherein the virtual network manager forwards the data packet to the virtual machine on a virtual network.

11. The method of claim **7** wherein the plurality of virtual machines are located on a plurality of host computers.

12. A computer-implemented method for sending data to a virtual machine on a host computer system, the method comprising the steps of:

(A) configuring multiple virtual machines located on at least one physical host computer with a single internet protocol (IP) address;

(B) configuring a virtual network manager with a port range table with a plurality of port ranges and a corresponding virtual machine number for each port range;

(C) routing an incoming data packet from a physical interface to a unique one of the multiple virtual machines based on a destination port number in the data packet by determining a virtual machine number corresponding to a port range in the port range table which includes the destination port number in the data packet and routing the data packet to the unique one virtual machine with the determined virtual machine number;

(D) discarding the incoming packet where the incoming packet is not allowed by a firewall;

(E) returning the incoming packet if the packet does not conform to a protocol chosen from the following: TCP (Transmission Control Protocol) and User Datagram Protocol (UDP);

(F) configuring ephemeral ports of the virtual machines to use port numbers in a range of port numbers in the port range table assigned to the virtual machine;

(G) wherein the data packet is routed on a virtual network.

13. An article of manufacture comprising software stored on non-transitory computer readable storage medium, the software comprising:

a virtual network manager that forwards a data packet with a destination port number received on a physical interface to a unique one of a plurality of virtual machines depending on the destination port number in the data packet, where the plurality of virtual machines share the physical interface having a single internet protocol (IP) address connecting a host computer to an external network, wherein the virtual network manager further comprises a port range table with a plurality of port ranges and a corresponding virtual machine number for each port range, and wherein the virtual network manager determines the virtual machine number of the unique one of the plurality of virtual machines by selecting the virtual machine number stored in the port range table corresponding to a port range that includes the destination port number in the data packet.

14. The article of manufacture of claim **13** wherein a firewall protects the host computer from the external network.

15. The article of manufacture of claim **13** and wherein the plurality of virtual machines are located on a plurality of host computers.

16. The article of manufacture of claim **13** wherein the virtual network manager forwards the data packet to the virtual machine on a virtual network

17. The article of manufacture of claim **13** wherein the data packets conform to a protocol chosen from the following: TCP (Transmission Control Protocol) and User Datagram Protocol (UDP).

18. The article of manufacture of claim **13** wherein ephemeral ports of the virtual machines are configured to use port numbers in a range of port numbers in the port range table assigned to the virtual machine.

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